



AGING SYSTEMS AT SLAC

Matt Gibbs

Accelerator Operations Specialist for LCLS

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LCLS, built in 2008

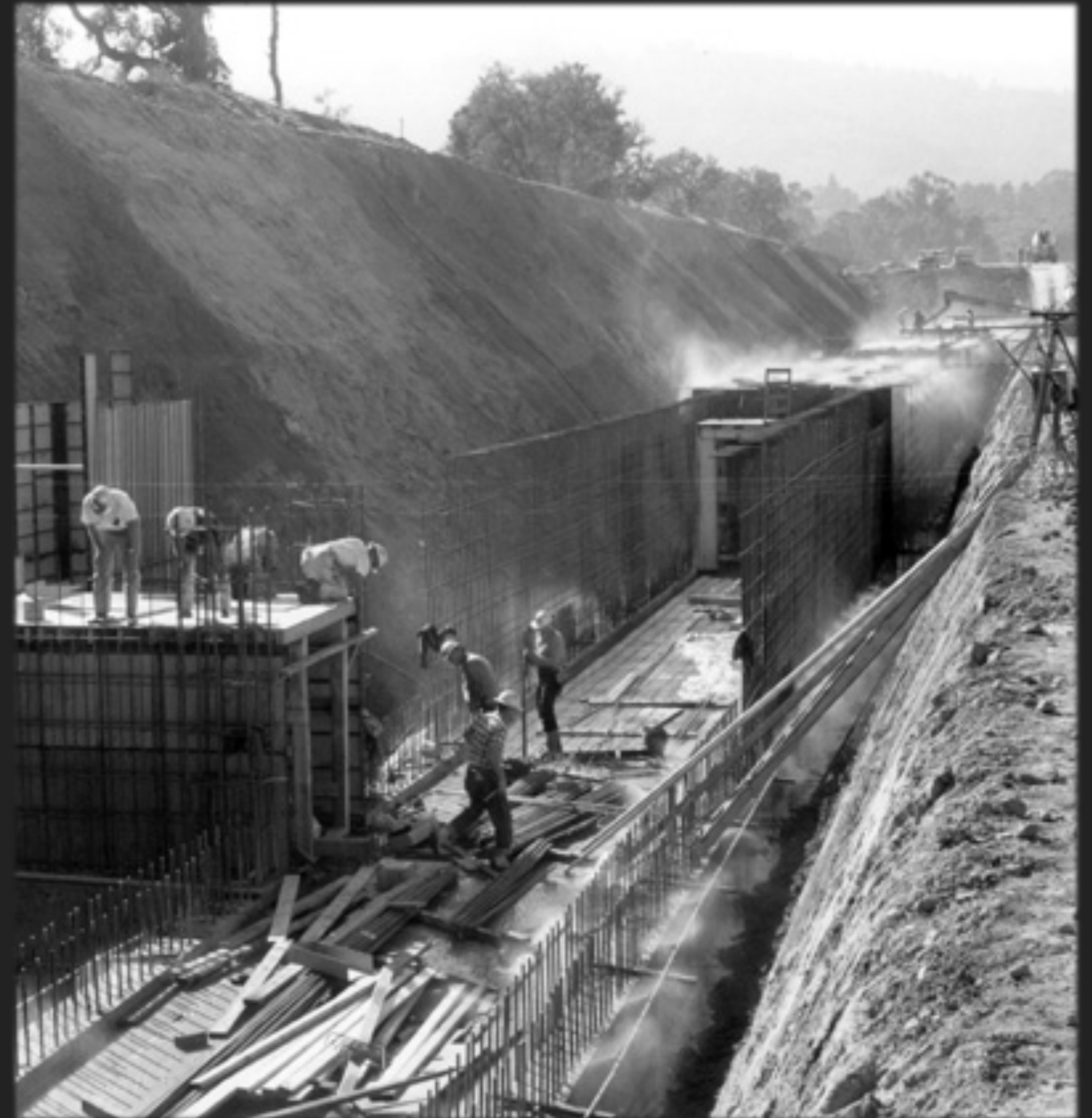
AGING SYSTEMS AT SLAC



SPEAR3, built in 2004

SLAC IS OLD

- ▶ Linac tunnel constructed in 1964 (pictured)
- ▶ First beam in the linac in 1966
- ▶ Pre-dates computerized control systems
- ▶ Pre-dates single-chip CPUs
- ▶ Pre-dates Programmable Logic Controllers
- ▶ Far surpassed lifespan expectations



AGING SYSTEMS AT SLAC



1966

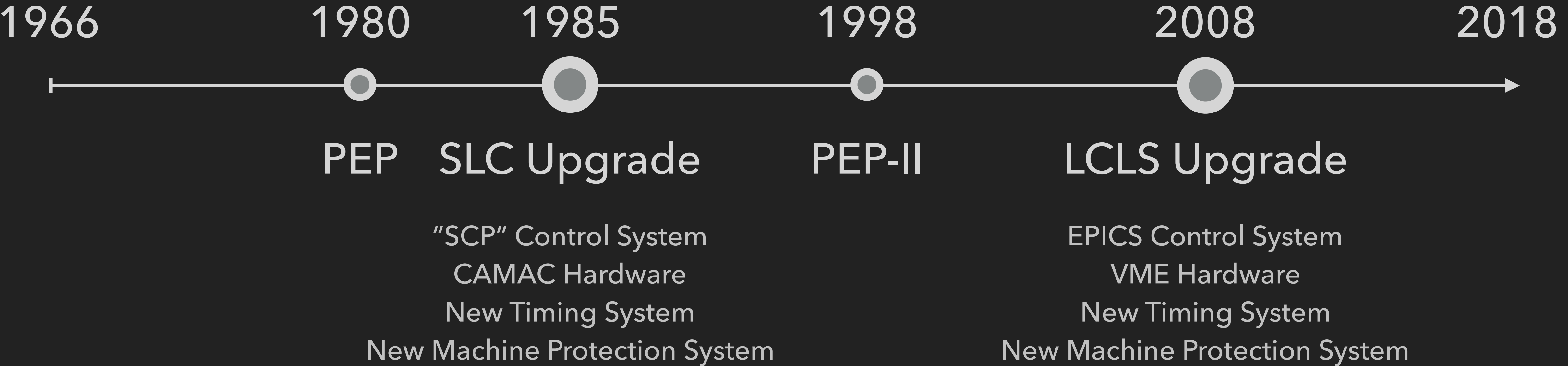


1974



2010

SLAC TIMELINE



UPGRADES ADD NEW THINGS, RARELY TAKE OLD ONES AWAY

- ▶ As time goes on, the number of different technologies to support grows:
 - ▶ Variants on a type of system
 - ▶ Software packages
 - ▶ “Quirks” to memorize

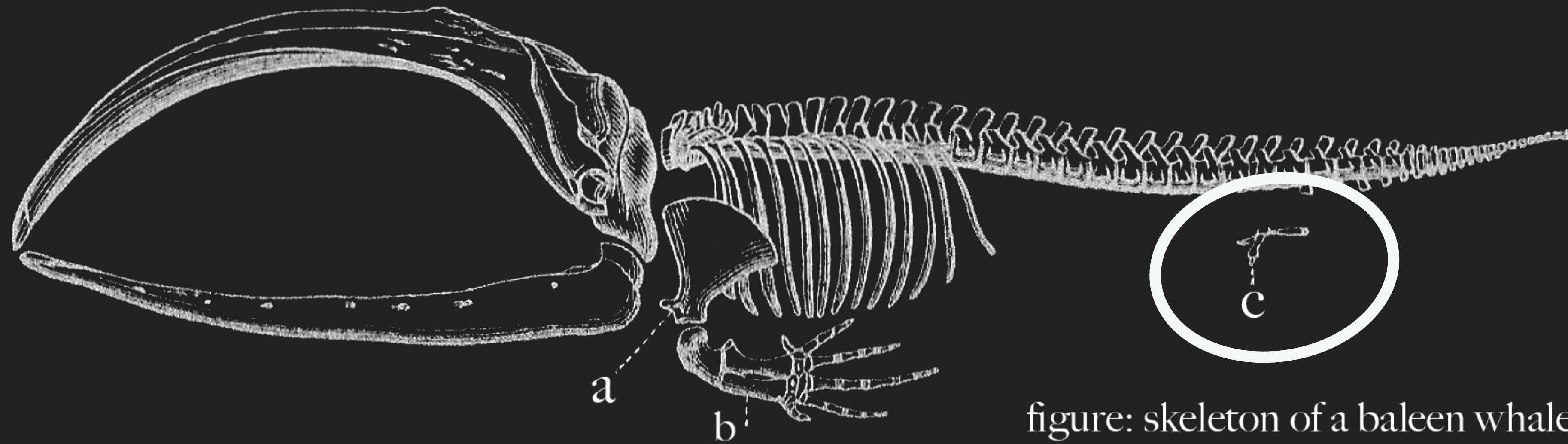


figure: skeleton of a baleen whale
(Pelvic bone circled)

VESTIGIAL SYSTEMS

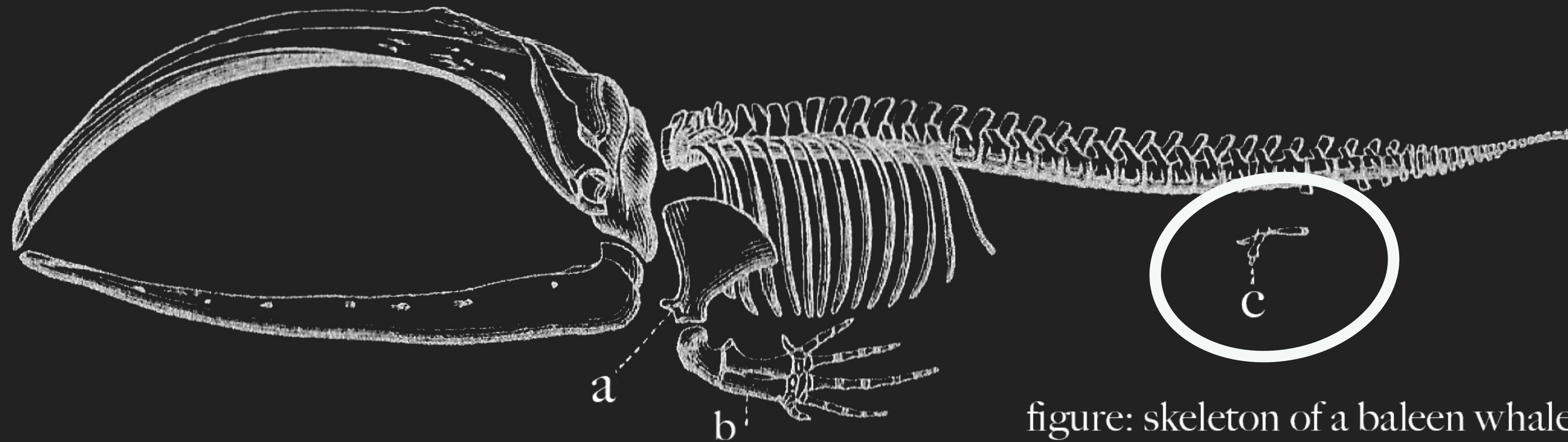


figure: skeleton of a baleen whale
(Pelvic bone circled)

- ▶ Control system interfaces for decommissioned equipment
- ▶ Obscure equipment that serves no function, but will trip the beam off when it fails

EXAMPLE: PPYY RELAY

- ▶ Backup shut-off path for the SLC/PEP-II Machine Protection System’s beam loss monitors. Stops broadcasting timing pattern to all devices.
- ▶ In the LCLS era, none of the loss monitors tied the PPYY relay existed in areas with beam. However, the relay still had spurious trips a few times per year.
- ▶ Status for the PPYY relay, and the reset button, requires navigating through a series of obscure, poorly labeled, visually indistinct panels.

| | | | | | | | |
|--------------------------------|--------------------|--------------------------|---------------------|--------------------|------------------------|----------------------|------------------------|
| EXIT | FACET / SLC INDEX | | | HALT DISPLY (ALL) | HELP | RETURN ESA_INDX | INDEX |
| Region Index Panels | | | | | | | |
| INJECTR Index | DAMPNG RINGS Index | LINAC Index | E+ SYSTEM Index | ARCS Index | FINAL FOCUS Index | CRYO LAB Index | FACET tuneup Index |
| Facilities & Special Functions | | | | PEP-II INDEX | FFTB Index | NLCtrA Index | R-Line Index |
| | | | | | | | LCLS INDEX |
| ALL MAGNET PANEL | BPM Device Panel | DIGITAL STATUS INDEX | ANALOG STATUS Index | KLYS Index | TIMING SYSTEM | POWER STEER | CONFIG Index |
| NETWRK MICRO Index | VIDEO Index | WIRE/ COLMTR Index | MULTI DEVICE KNOBS | CORR. PLOT Panel | BEAM Option Contr1 | MODEL SYSTEM Index | FEEDBK System Index |
| Display Functions | | | | OPERAT MAINT Index | SYSTEM BROWN-OUT Panel | MPS PPS ACCESS Panel | ALL REGNS BCS Panel |
| | | | | | | | ALARMS & WARNNGS Panel |
| SPECIAL DISPLY | PHONE DIREC-TORY | Print Cntrl Panel [shF4] | MCC ONLY Panel | | | | USER DEV PANELS |

| | | | | | | | |
|-----------------|--------------------|--------------------|--------------------------|---------------------|--------------------|-------------------------|-------------------------|
| | | | | UPDATE D. STAT | HELP | RETURN | INDEX |
| TFBK 1 TRACK | TFBK 2 TRACK | TRBR & RAW M THY 1 | TRBR & RAW M THY 2 | | NORTH INDEX | PRINT All Text FACETLOG | PRINT All Text FACETLOG |
| TFBK 1 FREEZE | TFBK 2 FREEZE | FINE HKB ALL BM | COARSE SYSTEM 1 BEAM | KHBSYS THY 1 ALBEAM | KICKER A CONTRL | IDOW CR7 N4 PANEL | BEAM PROMPT 10 SCAV e- |
| TFBK 1 INIT | TFBK 2 INIT | TIMING CONTRL | Kicker Timing Feedbk GIF | KHBSYS THY 2 ALBEAM | KICKER C CONTRL | IDIH CR7 N3 PANEL | ANALOG STATUS |
| TRACK? TRACKING | TRACK? TRACKING | TIME COUNTR | SYSTEM TIME DISPLY | | KICKER SHAP CONTRL | | ANALOG HISTRY |
| RANGE? IN_RANGE | RANGE? IN_RANGE | LQPS28 B SYSTEM | PREKIK SHPS PANEL | TUNER STEP PANEL | | | N KICK RSCOPE |
| WINDW? INSIDE | WINDW? INSIDE | ENTER HKB INCR | RESTOR KNOB | ASSIGN KNOB 0 | ASSIGN KNOB 1 | ASSIGN KNOB 2 | ASSIGN KNOB 3 |
| LQPS OFF | LQPS 10 MIN STRTUP | LQPS 10 MIN STRTUP | ENTER BDES | TRIM | DISPLY ALL UNITS | DISPLY SINGLE UNIT | MAGNET DIAGNS PANEL |

| | | | | | | | |
|------------------------------------|-----------------------------|------------------------|-------------------|---------------------|------------------------|-----------------------|-------------------------|
| SLC BPM MEAS | MISC BPM MEAS | BPM Range Panel | BPM Range Panel | MORE BPM DIAGS | HELP | RETURN | INDEX |
| Special Display Groups | | | | | BPM Rate Disply | Beam Rate Disply | PRINT All Text FACETLOG |
| CID- BAS 10 | LINAC | DEBUMP NDRFACET | PP BEAM# 10 | Cal Range DR12 LI20 | CAL BPM0 | Bad Cal Disply | INCR PAGE 1 |
| SCAV LINAC CHICN | FFTB LINAC CHICN | Enter DGRP NDRFACET | Bunch 1 | e- | CalDsp Range DR12 LI20 | Cal Disply | Display Next Page |
| DE Meas Def | Sum Yield Def | Extra Global Defs <--- | TS ANY | BEAM CURRNT e- 2.0 | LIST OLDPUB CALIBS | Currrnt Cal is PRIVAT | Display Prev Page |
| FFTB e+ Linac | SLC dummy e- | Super Asset e-(e+) | BUNCH DELAY 0.000 | ARC BEAM CURRNT 1.8 | LOAD OLDPUB CALIBS | MAKE CALIB PUBLIC | Display Last Page |
| Super Asset e-(e-) PP= 10 NDRFACET | BPM Measurement Definitions | | | | PP= 10 NDRFACET | PARTL UPDATE PUBLIC | CAL DOWN LOAD |
| CREATE MEAS DEF | DR12 LI20 e- B1 | | | | DR12 * LI20 e- B1 | UPDATE PUBLIC DEFLT5 | CANCEL MEAS DEF |

| | | | | |
|------------------------------|----------------------------|--------------|--------------|--------------|
| MODEL SYSTEM INDEX | | HELP | RETURN | INDEX |
| MODEL APPLI- CATION | | | CF_SKELS | |
| CONVERT AND LOAD | | | | |
| BEAM CODE 1 LCLS_E- | START ENERGY FROM 5001BEND | BOES TO KMOD | BACT TO KMOD | BCON TO KMOD |
| | | KMOD TO BOES | | KMOD TO BCON |
| SELECT MAGNETS FOR DGRP TRIM | | | | |
| DGRP TRIM | ALL MAGNET | ALL LQPS | ALL QUAD | ALL QTRM |
| | | ALL BEND | | |
| | | ALL SEXT | ALL SEPT | ALL XCOR |
| | | | | ALL YCOR |

PPS/BCS Status Display

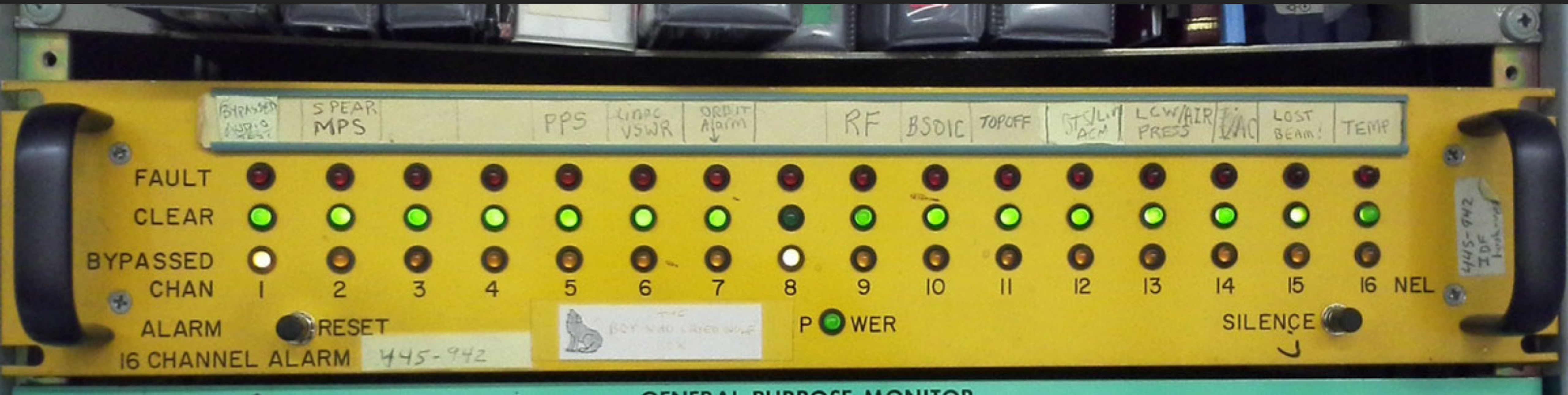
PPYY



PPS 21-29: OK PPS 30-MCC: OK PPS UND: OK

| | | | | |
|-------|----------|-----|--------------------------|------------|
| 09/28 | 09:18:04 | PPS | NEH Hutch 2 Stopper S2.2 | NOT_IN |
| 09/28 | 09:14:55 | PPS | NEH Hutch 2 Search Reset | SET |
| 09/28 | 09:11:48 | PPS | XRT Search Reset | NOT_SET |
| 09/28 | 09:11:41 | PPS | XRT ACCESS STATE | CONTROLLED |
| 09/28 | 09:11:21 | PPS | XRT SH2.1 | NOT_IN |
| 09/28 | 09:11:21 | PPS | XRT SH2.2 | IN |
| 09/28 | 09:09:06 | BCS | B911 BX3/BYD - DTC 1 | OK |
| 09/28 | 09:09:06 | BCS | B911 BX3/BYD - DTC 2 | OK |

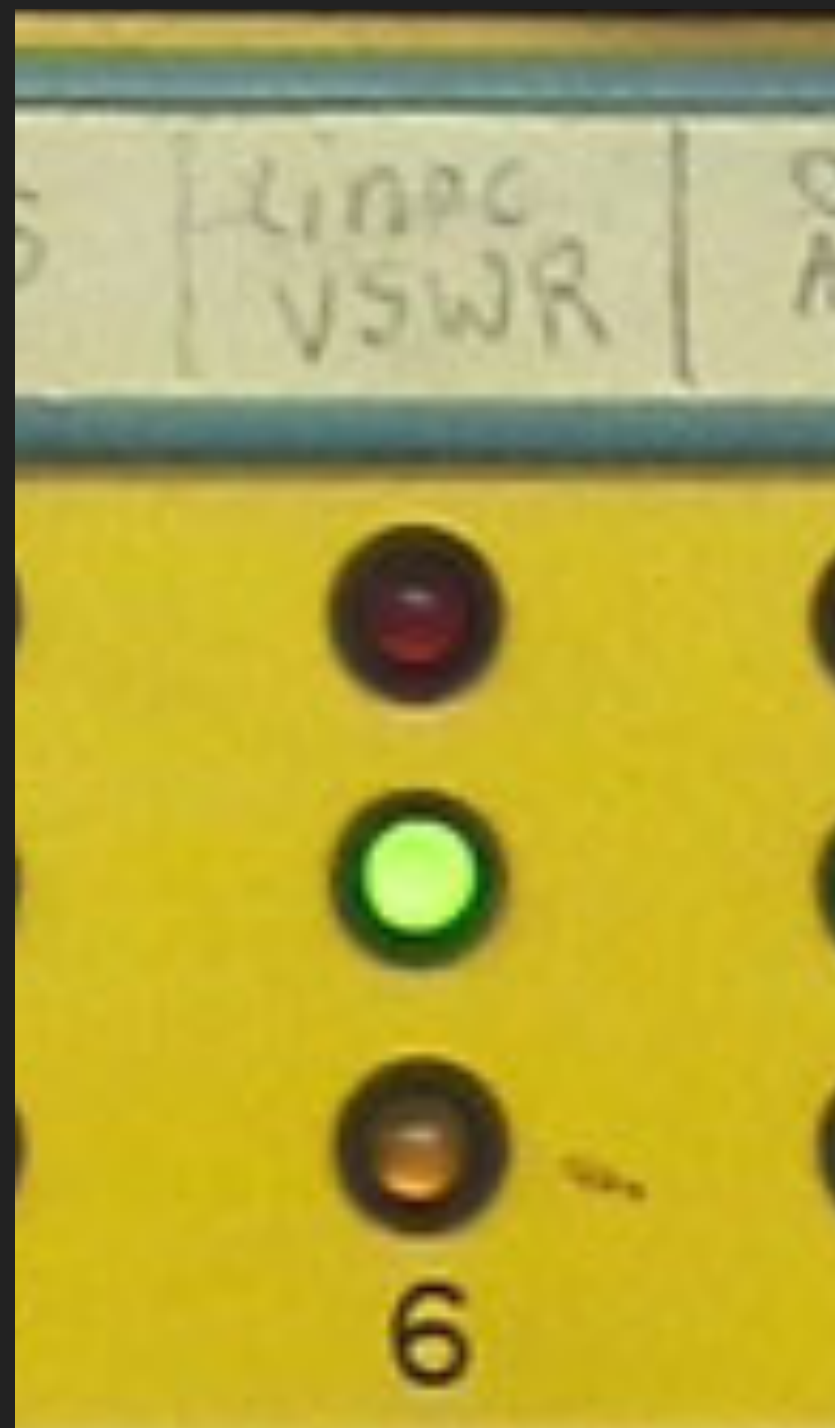
EXAMPLE: SPEAR3 "WOLF BOX"



EXAMPLE: SPEAR3 "WOLF BOX"



EXAMPLE: SPEAR3 "WOLF BOX"



- ▶ Linac VSWR (Voltage Standing Wave Ratio) alarm originally indicated a klystron reflected energy issue.
- ▶ The VSWR interlock shuts off the linac klystron, which is also a convenient way to shut off the beam.
- ▶ Many other systems (Average Current Monitors, Ion Chambers, etc) were wired into the VSWR interlock.
- ▶ Reflected energy is almost never a problem, so the klystron's VSWR is almost never the problem.

"WOLF BOX" DOCUMENTATION

- ▶ Extensive wiki documentation for every alarm channel (more than 7000 words!)
- ▶ Explains what can cause each alarm and how to respond (who to contact, what to document, how to reset)
- ▶ Painstakingly researched and written by a brand-new operator who was fed up with the chaos of the alarm system.

Main Display

Go to SPEAR INDEX --> NON-EDM Launcher --> Injector Menu -

BEAM CONTAINMENT SYSTEM

| | ACM #1 | ACM #2 | ACM #3 | VSWR INTLK |
|-----------------|---------------------|---------------------|---------------------|------------|
| Trip current | 0.04 | 0.02 | 0.00 | |
| Average current | 0.00 | 0.00 | 0.00 | |
| | OK RESET TEST | OK RESET TEST | OK RESET TEST | RESET |

K2 VSWR OFF
K3 VSWR OFF
ON OFF
OFF PUSH PUSH

BSOIC MAP

BSOIC STATUS
INJECTOR OK
SPEAR TRIPPED
(also BTS STOPPERS)

MODULATOR EMERGENCY OFF OK
MODULATOR TRIGGERS OFF
RF AMP TRIGGER OFF

INTERLOCK OK
MPS PLC MODULATOR TRIGGER PERMIT DISABLED
MPS PLC RF AMPLIFIER TRIGGER PERMIT DISABLED

Last update: 09 June 2017



How to Respond

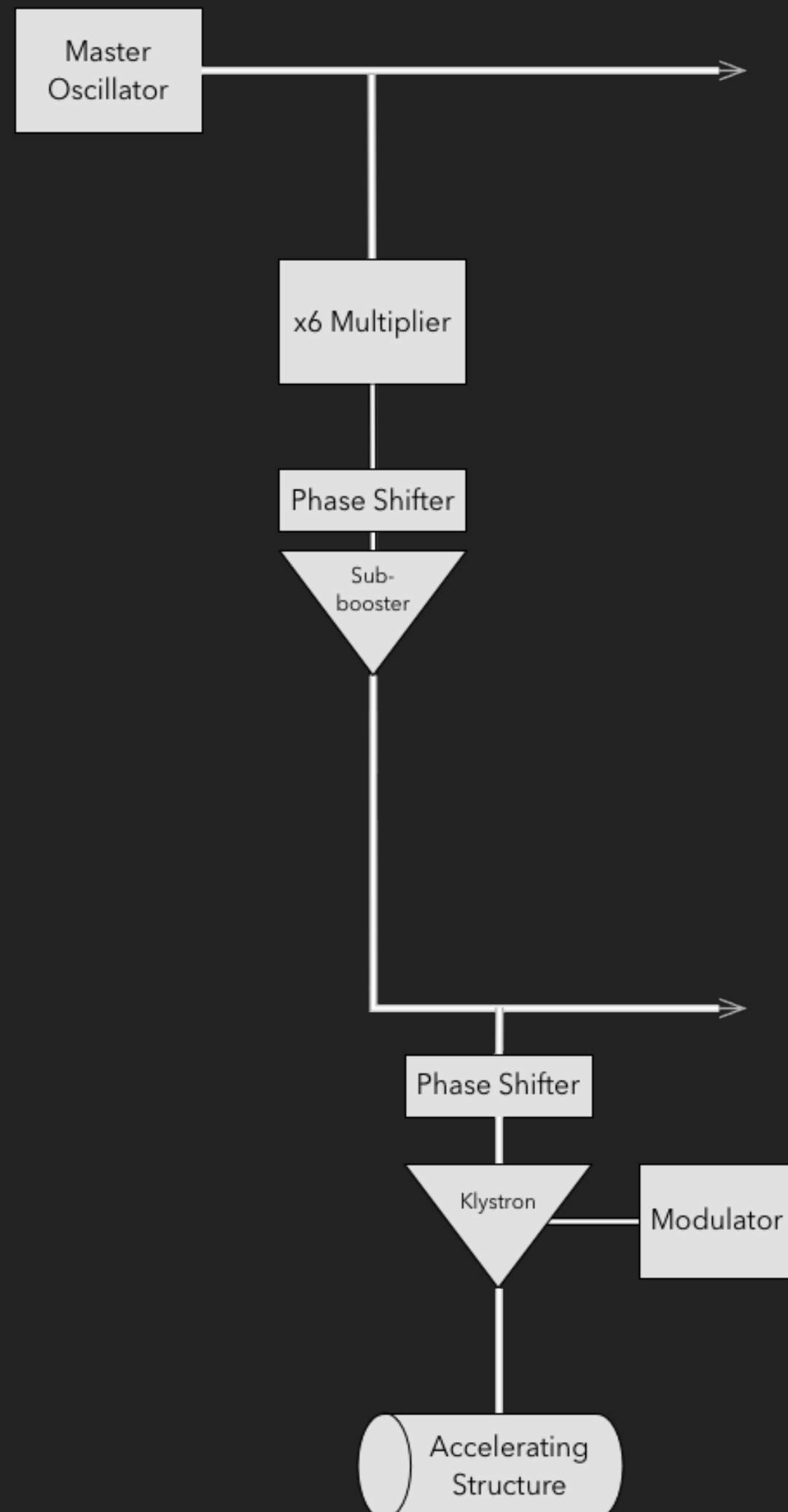
As stated in the overview there are many common BCS faults that are tied into the VSWR chain to turn the supply to the gun and linac, so I have listed some of the more common faults:

- There is a BSOIC located above the linac room, which is tied into this BCS chain (most common)
- There are 3 ACM's that will trip the VSWR if a high current reading is recorded (read more about it in the [ACM](#) section of this page)
- Chopper Interlock faults
- Modulator faults

The general procedure to follow if you get a VSWR fault is to first find out the exact cause of the VSWR fault, get that individual piece back to normal operating conditions, and then finally resetting the VSWR fault. For example, if the BSOIC above the linac tripped, you would first try and reset the BSOIC (after following

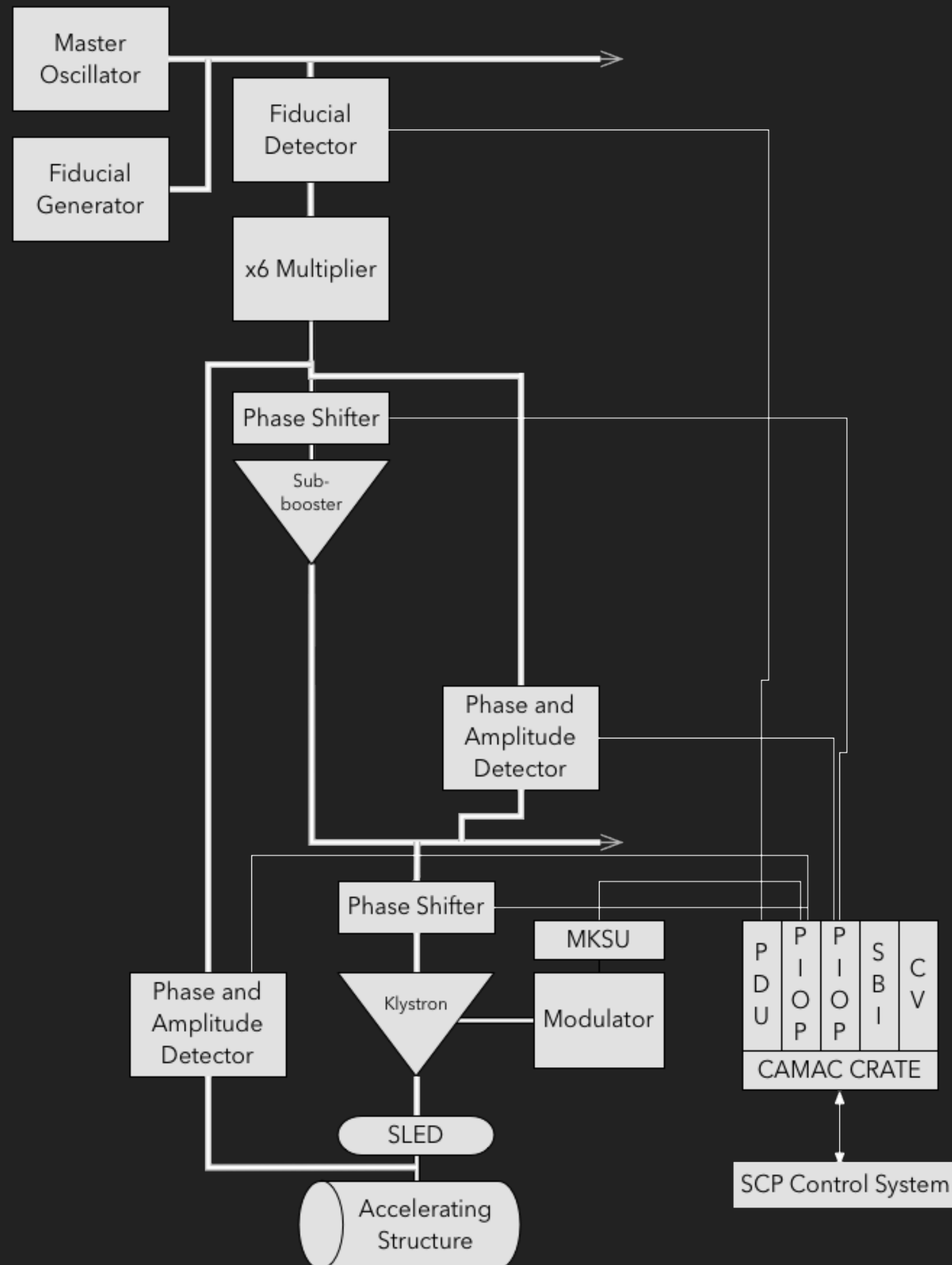
EXAMPLE: THE KLYSTRON SYSTEM

- ▶ 8 major components
- ▶ Operator interface in control room:
 - ▶ One on/off control
 - ▶ Three status indicator lights



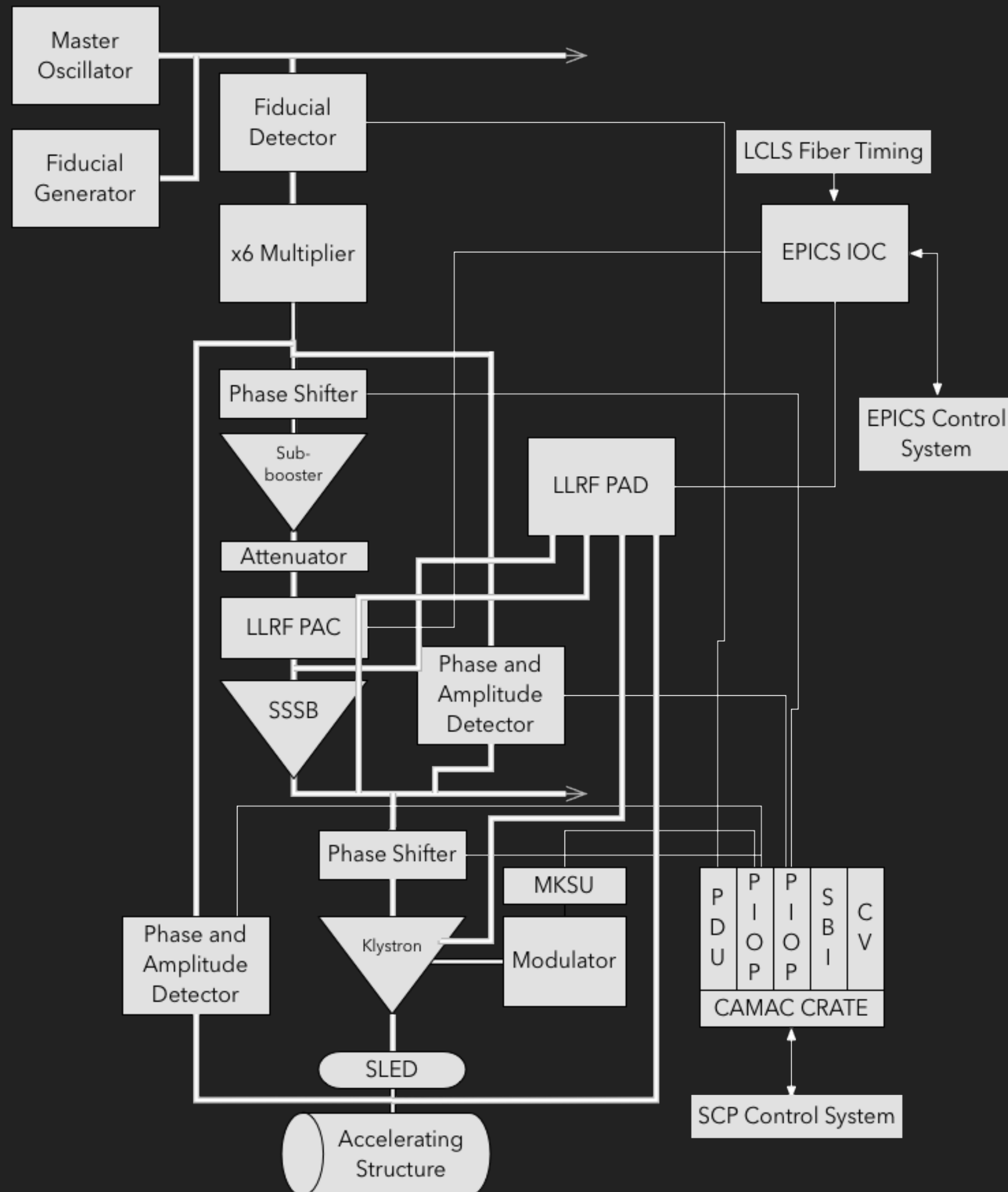
EXAMPLE: THE KLYSTRON SYSTEM

- ▶ 16 major components
- ▶ CAMAC controls hardware
- ▶ Nearly every piece has a control system interface



EXAMPLE: THE KLYSTRON SYSTEM

- ▶ 23 major components
- ▶ CAMAC and VME hardware, each using a different control system
- ▶ Much of the old phase control hardware still exists, and is controllable, but its purpose has been supplanted by new LLRF system



MITIGATING COMPLEXITY

- ▶ “Operations Klystron Panel” UI that handles some of the differences between old and new-style stations, providing a single interface
- ▶ Documentation in our Operations Wiki
- ▶ Training
- ▶ But, still pretty challenging.

STRATEGIES FOR DEALING WITH OLD AND COMPLICATED SYSTEMS

Training

ASO-1 Qualification Workbook

ASO-1 Qualification Workbook

Operator Supervisor approval: Paul 9/11/14 P. Schuh

EOIC Supervisor approval: Paul 9/16/14 M. Stanek

AD Safety Office: Paul Miller 8/20/2014 P. Miller or Z. Van Hoover

Introduction

The purpose of the ASO-1 Qualification Workbook is to ensure that operators receive a uniform level of training. It provides a means to ensure that no major training topics are missed over the course of that training. The workbook is written so that operators who have been actively participating in control room activities and following up with questions can complete the workbook in ten months.

Anyone who has completed the ASO-1 Qualification Workbook can serve as your trainer. Each item is to be initialed by a trainer after you have demonstrated that you understand the topic. You need not have the same trainer for all line items in a subsection. In fact, as you progress through the book, you will find that different trainers have special expertise in different areas, and it is helpful to have different people train you to get a more complete perspective on a topic.

The workbook sections may be completed in any order, but Section 2 will be especially useful for new operators. Feel free to skip between topics as they come up in your control room training.

Trainee (Print Name):

Qualification Started (Date):

Qualification Completed (Date):

Accelerator Operations Department Final Approvals (Signature/Date):

AOSD Operator Supervisor:

AOSD EOIC Supervisor:

AOSD Director:

August 15, 2014

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ASO-1 Qualification Workbook

What is the difference between SASE and seeded FEL?

Know when to adjust HXRSS/SXRSS phase trims when tuning for SASE beam

Beam based alignment

What is beam-based alignment? What is it correcting?

How does it work?

What is the outcome of loading an old configs for a region that has recently undergone BBA?

4.4 Navigating Networks and Applications

Goals: To provide new operators with a basic understanding of how to navigate the different controls and computing infrastructures, and point them to the resources that might help them get started on future computing projects.

UNIX

From an OPI, know how to pull up terminals for both the LCLS and FACET programs

Know basic UNIX commands: cd, ls, mkdir, cp, rm, pwd, ..., *, top

Know how to kill a bad process

Set up your profile for physics and fphysics. Why do you need your own profile?

MATLAB

How do you launch a Matlab session?

How do find the location/view the content of a production .m file?

If a Matlab GUI dies, what should you type into the terminal window before closing it?

What are lcaget and leaput? How do you use them?

EDM

Know how to launch EDM

Make a simple EDM panel that strip charts a PV

Know where to find more help on EDM

VMS

Know how to open a VMS terminal

Know how to launch a SCP, and know what makes COWs so special

Know how to find help on the "function keys"

Know how to print to different logbooks and printers from the SCP print

Know how to change directories

Know how to use the terminal 'help' functions

Have a senior op demonstrate how to use erdisp and access (or, demonstrate it yourself)

Know where to get more help (DFH)

CVS

What is CVS? When should you use it?

Read through the CVS for Dummies MCCWiki page.

To check out files, which profile do you have to be under?

What extra step is needed to perform an update Matlab prod files?

Know how to find DFH help on CVS for VMS

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ASO-1 Qualification Workbook

If a feedback starts running away (after a klystron trip, etc.), how might you start recovering the beam? (Longitudinal, transverse, bunch charge...)

4.7 Control Systems

Goal: To become familiar with the various control systems used for LCLS, FACET, SPEAR and A Line. Be able to answer the comprehensive questions below.

Trainer: This section can be completed by giving a 30 minute talk about each control system below. Describe how each subtopic is managed in the different control systems. You may find it helpful to draw a diagram describing how the different subtopic devices are connected. Give enough detail that the trainee will be able to answer the comprehensive questions below.

FACET / A Line Control System

Architecture organization: centralized (Mainframe (Alpha/VAX) and terminal (SCP))

Data storage

Device configuration

Alarms

Network (SLCNet, PNet)

Applications: SCP based

Micro components

CPU

Memory board

PNet board

FSK Modem

Multi Bus Camac Driver board

CAMAC

Serial Crate Controller

Crate Verifier

Programmable Delay Unit

Simple Timing Buffer

Programmable Input/Output Processor

DAC/SAM

IDIM/IDOM

Error logs

LCLS control system

Architecture organization: distributed

Data storage

Device Configuration

Alarms

Network (channel access, timing)

Applications: Matlab / Java / Python

VME IOCs, Soft IOCs, Embedded IOCs, PLCs

CMlog

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Excerpts from the "ASO-1 Qualification Workbook"

STRATEGIES FOR DEALING WITH OLD AND COMPLICATED SYSTEMS

Documentation



[Main Page](#)
[Recent changes](#)
[Help](#)

Accelerator Programs

- LCLS
- LCLS-II
- ESA
- PEP
- FACET
- SPEAR3

Control System

- General Software
- General Hardware
- LCLS Home

[Main page](#) [Discussion](#) [Read](#) [View source](#) [More](#)

Main Page

MCC Operations Wiki

News

9/21/2018 Added [Wolf Box Alarm](#) information page (SPEAR)

9/6/2018 Added [BSY search animation PPTX](#) to Training -> PPS Training

6/28/2018 [Matterport Scan of LCLS Undulator Hall](#)

6/06/2018 [ACR Daily Shutdown/Startup](#)

5/14/2018 Reposting our favorite equation since it disappeared from the main page! $\lambda_0 = \frac{\lambda_u}{2\gamma^2} \left(1 + \frac{K^2}{2}\right)!$


04/25/2018 Added [Wide X-ray Bandwidth](#).

02/13/2018 Added [Pulling Fast and Slow valves](#).

Operations Group Wiki

Sector 20 Optics and Tuning

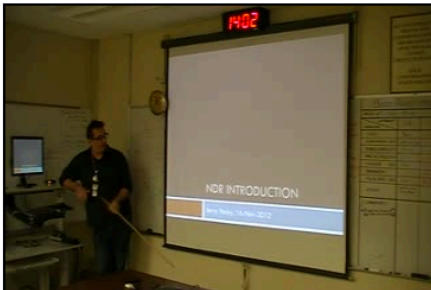
by [Nate Lipkowitz](#) on 2012-11-30



Nate discusses how to tune the beam for the experiments in sector 20. The optics which match the linac's FODO lattice into the W chicane in LI18 are described, as are the diagnostic tools available (bunch length monitor, wire scanner). The scavenger extraction line is also covered. The operation of the HLAM is presented. Ways to evaluate beam quality based on the PR-185 image are discussed. The W chicane optics, R56 of the chicane, and chromatic corrections from the sextupoles are shown. Sextupole tuning is discussed. SYAG, a profile monitor which can look at either synchrotron light from the FACET beam, or the FACET beam itself, is mentioned as a diagnostic tool. Strategies for tuning to minimize spot size are offered.

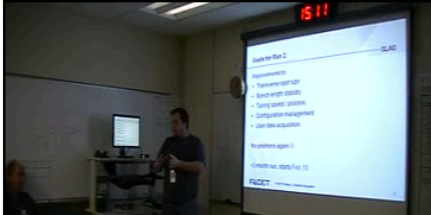
Damping Ring Setup and Tuning

by [Jerry Yocky](#) on 2012-11-16



FACET Upgrades and Changes - Preparations for Run 2 - Part 2

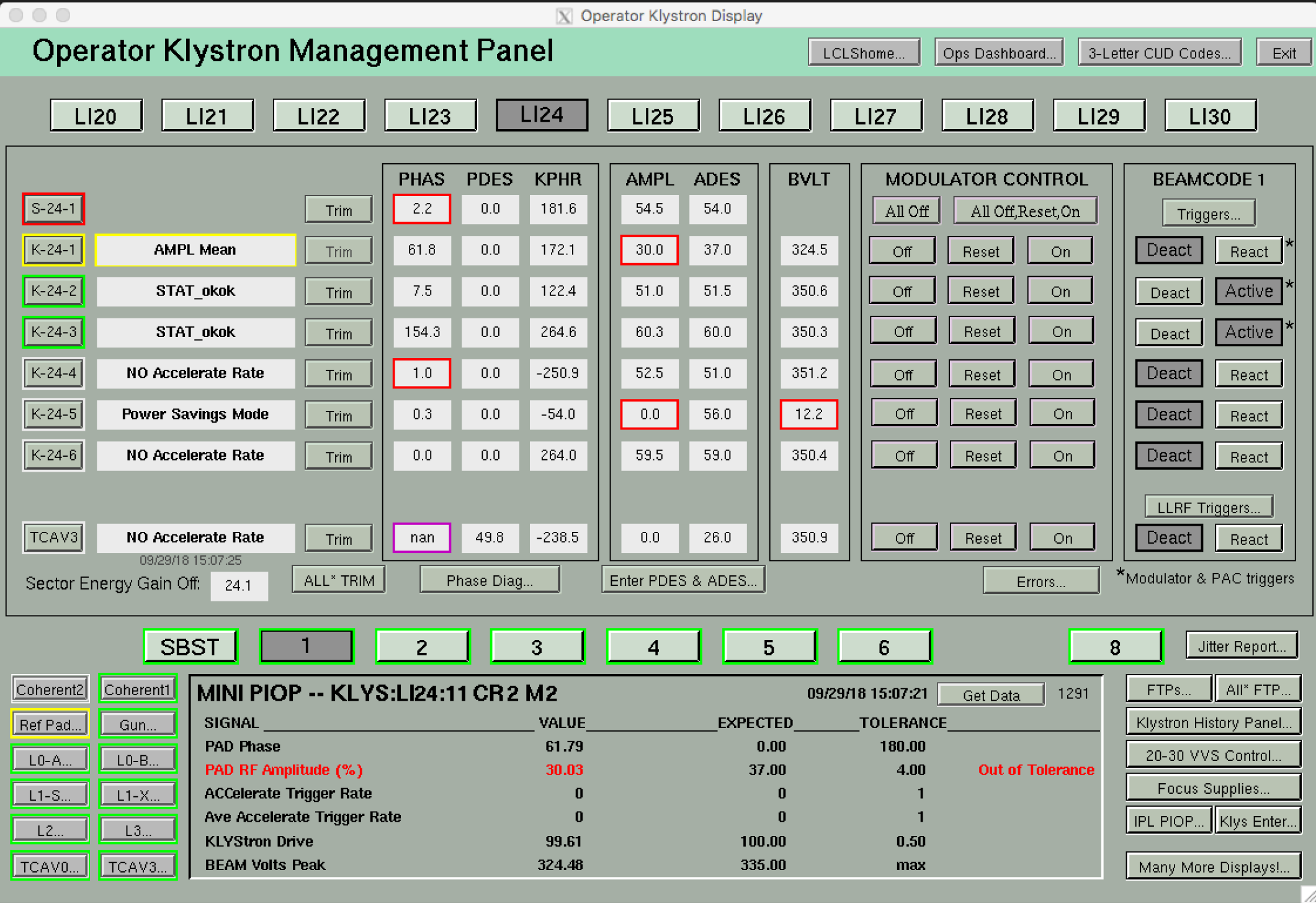
by [Nate Lipkowitz](#) on 2012-11-09



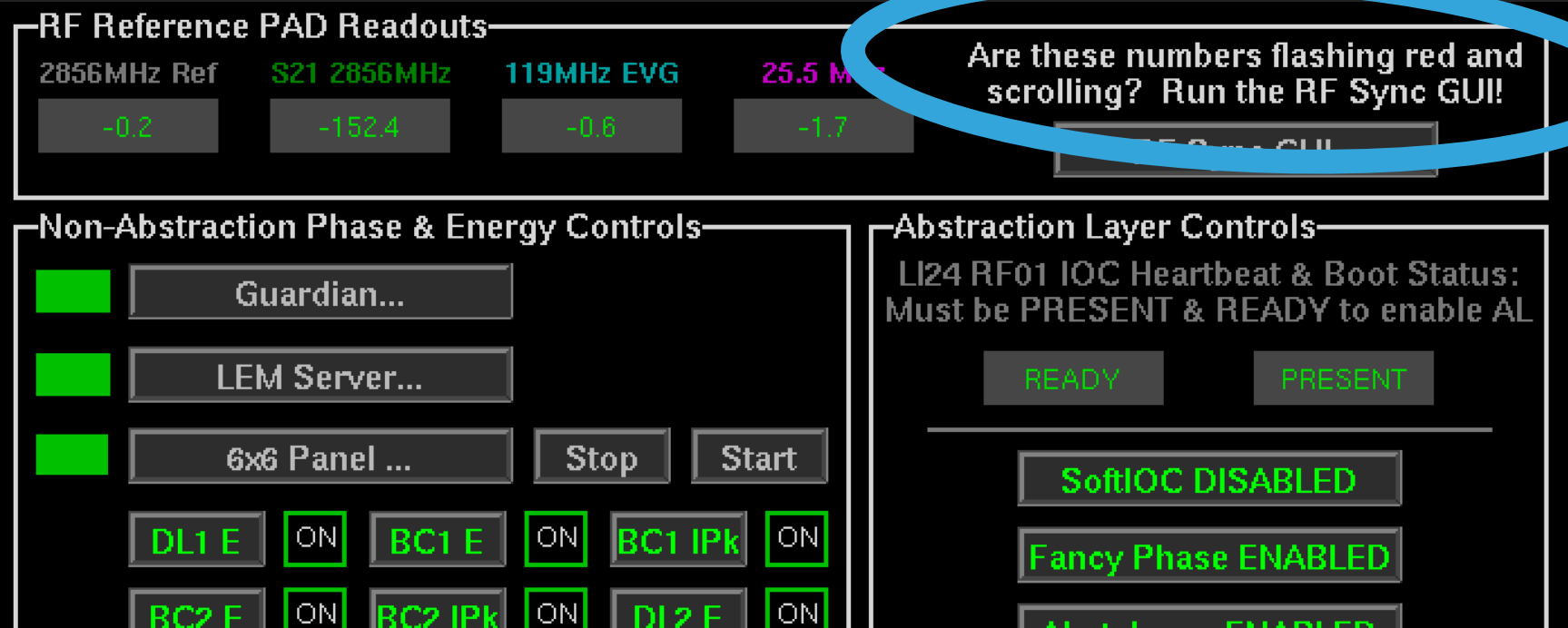
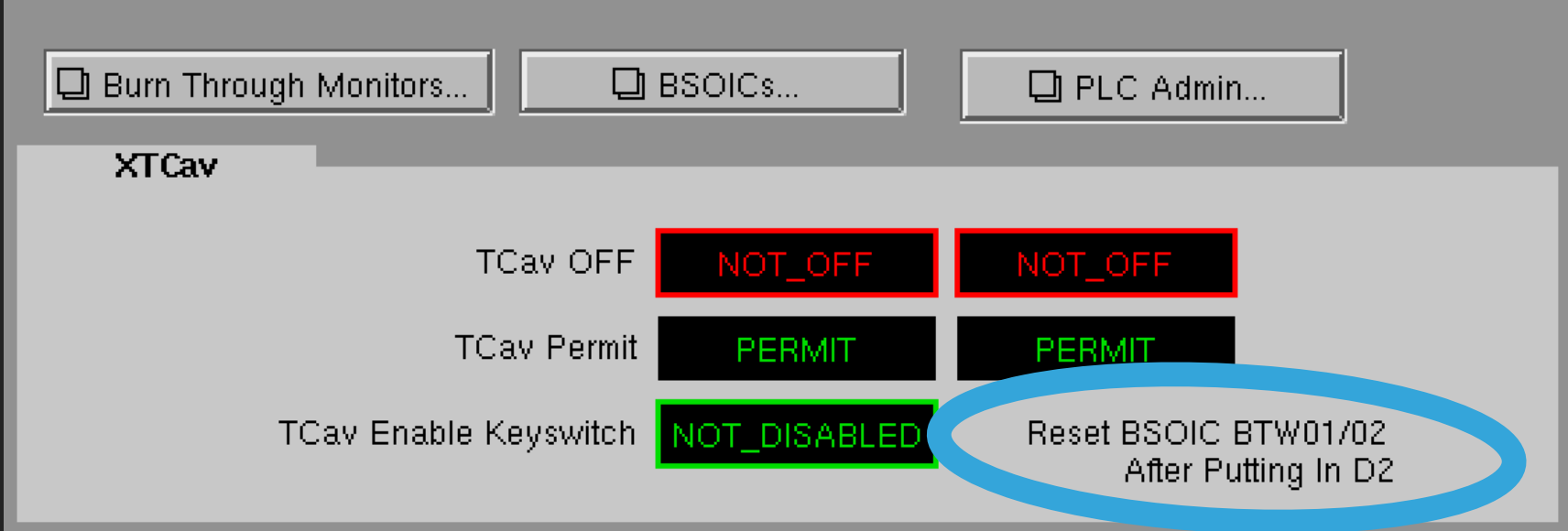
"MCCVideos" Video Database

STRATEGIES FOR DEALING WITH OLD AND COMPLICATED SYSTEMS

Operator-created (or operator edited) Control System Displays



Operator Klystron Panel



Reminder notes written on control panels

THANKS!

Acknowledgements:

- ▶ Howard Smith, Peter Schuh, William Colocho, Danielle Sanzone, and Lauren Alsberg for their helpful conversations about this subject
- ▶ Vikram Tharakan for the Wolf Box wiki page
- ▶ Shawn Alverson for the gigantic flashing "PPYY" text